“Lambda Net / Lambda Rail”

Information for Meeting with ARC’s Peter Friedland at GSFC on 01/22/04

J. Patrick Gary/930, 301-286-9539, pat.gary@nasa.gov

Jeff Smith/585, 301-614-5038, jeff.smith@nasa.gov

Milt Halem/UMBC, 301-614-6598, Milton.Halem-1@nasa.gov

Mike Seablom/586, 301-286-2406, Michael.S.Seablom@nasa.gov

“Lambda Net / Lambda Rail”

Topics

- GSFC Prior/Present Experience with Optical Networking/High End Computer Network Capabilities
- GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure”
- Future R&D Interests (partial)
- Q&A’s, especially to develop stronger partnerships between ARC and GSFC in these areas

GSFC Prior/Present Experience with Optical Networking/High End Computer Network Capabilities

1 of 2

- Prior Experience with Optical Networking Technologies
  - » 8x10 Gbps lambda switches (Lucent, Tellium) in MONET/ATDnet
  - » 2x1 Gigabit Ethernet (GE) aggregated link with Mid-Atlantic Crossroads (MAX) gigapop at UMCP using LuxN CWDM's
  - » 10 Gbps link with MAX at UMCP using LuxN CWDM's
- Present High End Computer Network Capability
  - » GSFC-local jumbo-frame-capable Science and Engineering Network (SEN)
    - – 1-4 GE aggregated links in inter-building backbone among buildings 22, 23, 28, 32, & 33
    - – 1-2 GE aggregated links in intra-building infrastructure
    - – 2 Gbps linking with MAX & Abilene
  - » Examples of New Applications
    - – eVLBI: 1 Gbps between GSFC and MIT/Haystack
    - – SAN-over-IP Pilot: iSCSI (Cisco) w/UMCP, iFCP (Nishan) w/UCSD, FCIP (SANcastle) w/NCSA

GSFC Prior/Present Experience with Optical Networking/High End Computer Network Capabilities

2 of 2

- Next Generation Technologies in Review
  - » 10 GE for local SEN and its link with MAX & Abilene
    - – Force10 E300 router; Intel and S2IO NIC's; PCI-X based PC's
  - » Movaz iWSS and RAYexpress optical switches via NSF-funded DRAGON/UMCP-USC-GMU project
  - » UMBC CASPR optical switch by Dr. Ray Chen
  - » Marconi OADM's in EOSDIS Network Prototyping Lab
- New Technologies in GSFC FY04 IRAD Proposal
  - » Linking Beowulf cluster computers and SAN's via optical switch/routers
  - » 10 Gbps per lambda
  - » Lambda network services
  - » Higher performing transport protocols

GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Objectives Summary

- "…establish a "Lambda Network" (in this case using optical wavelength technology and 10 Gbps Ethernet per wavelength) from GSFC's Earth science Greenbelt facility in MD to the Scripps Institute of Oceanography (SIO) through the University of California, San Diego (UCSD) facility over the National Lambda Rail (NLR), a new national dark optical fiber infrastructure."
- "…make data residing on Goddard's high speed computer disks available to SIO with access speeds as if the data were on their own desktop servers or PC's."
- "…enable scientists at both institutions to share and use compute intensive community models, complex data base mining and multi-dimensional streaming visualization over this highly distributed, virtual working environment."

GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Examples of Initial Primary Users/Applications (1 of 2)

- Drs. Paul Houser and Mike Bosilovich of Code 970 are collaborating with Dr. John Roads of SIO on the Coordinated Earth Observing Program under GEWEX
- Dr. Roads with Dr. Max Suarez of Code 900.3, Mike Seablom of Code 560, and a UMBC graduate student working with Dr. Milton Halem, GSFC Emeritus, plan to run interactive distributed regional model forecasts using boundary forcing conditions from the Global Modeling and Assimilation Office (GMAO) global climate model
- Dr. Yoram Kaufman of Code 910 is collaborating with Dr. Ramanathan of SIO on an Aerosol project
- Dr. J. Herman of Code 910 is the Co–I with Dr. Francisco Valero of SIO who is the PI on the Triana mission

GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Examples of Initial Primary Users/Applications (2 of 2)

- Dr. Michelle Rienecker of Code 900.3 is collaborating with Dr. Tim Barnett of SIO on the assimilation of global sea height data from TOPEX and GRACE
- SIO's Prof. Richard Sommerville has one of his modelers remotely providing computational science support to the NCCS of Code 930
- Code 920 has collocated one of its geophysical scientists at SIO
- UCSD's Geosciences Network PI Dr. Dogan Seber has identified some of GSFC's solid earth research data sets and models for developing collaborative research efforts with Dr. Weijia Kuang and others from Code 920

GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Key Aspects of Technical Approach (1 of 2)

- Transcontinental Networking
  - » Either in partnership with the NREN Project, or directly through a Mid-Atlantic Terascale Partnership membership arrangement, become a member in the NLR
    - – Gain rights to use NLR's national optical network infrastructure
    - – Add GSFC-SIO lambda service between UCSD and McLean, VA
- Regional Networking between NLR at McLean and GSFC (UCSD/SIO will provision their end)
  - » Either obtain experimental lambda service extension in partnership with MAX, or lease dark fiber from Level 3 (directly or in partnership with the NREN Project) and provision other needed optical network components
    - – Costs are similar for either approach
    - – MAX approach has greater future "local fan out" possibilities, but may not meet our timeline requirements

National LambdaRail (http://www.nationallambdarail.org/)

- Provide an enabling network infrastructure for new forms and methods for research in science, engineering, health care, and education as well as for research and development of new Internet technologies, protocols, applications and services.
- Provide the research community with direct control over a nationwide optical fiber infrastructure, enabling a wide range of facilities, capabilities and services in support of both application level and networking level experiments and serving diverse communities of computational scientists, distributed systems researchers and networking researchers.

GSFC FY04 IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Key Aspects of Technical Approach (2 of 2)

- Intra-GSFC Networking (UCSD/SIO will provision their end)
  - » Initially interconnect with the SEN and *Thunderhead* cluster in building 28
  - » Use optical switches/routers for new experimental inter-building infrastructure
    - – Movaz iWSS and RAYexpress optical switches from DRAGON/UMCP-USC-GMU
    - – 8-way lambda optical crossbar from Dr. Ray Chen/UMBC
- "Seed Application"
  - » Integrate Earth System Modeling Framework software with grid middleware by constructing prototype interfaces between the components
  - » Identify requirements for new methods and/or messages that would be desirable for supporting GSFC models and data assimilation

Future R&D Interests (partial) (1 of 2)

Information Technology Oriented

- OptIPuter development with Dr. Larry Smarr/UCSD
- Intra-NASA/inter-Center SAN-over-IP Testbed with ARC and JPL
- HDTV-over-IP streaming/multicasting to enhance distributed collaborations
- Data web development with Dr. Robert Grossman/UIC

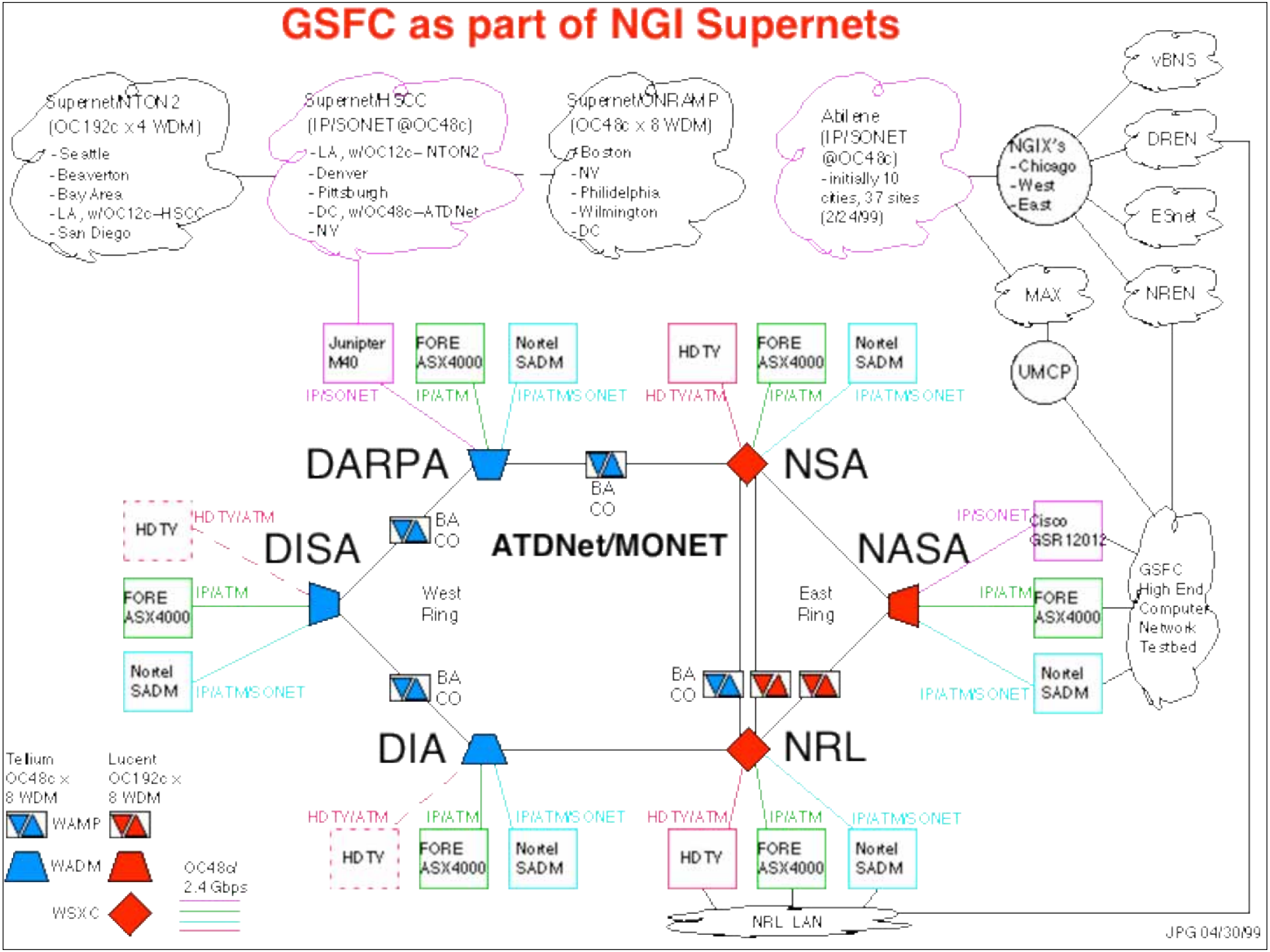
Future R&D Interests (partial) (2 of 2)

New Users/Applications Oriented

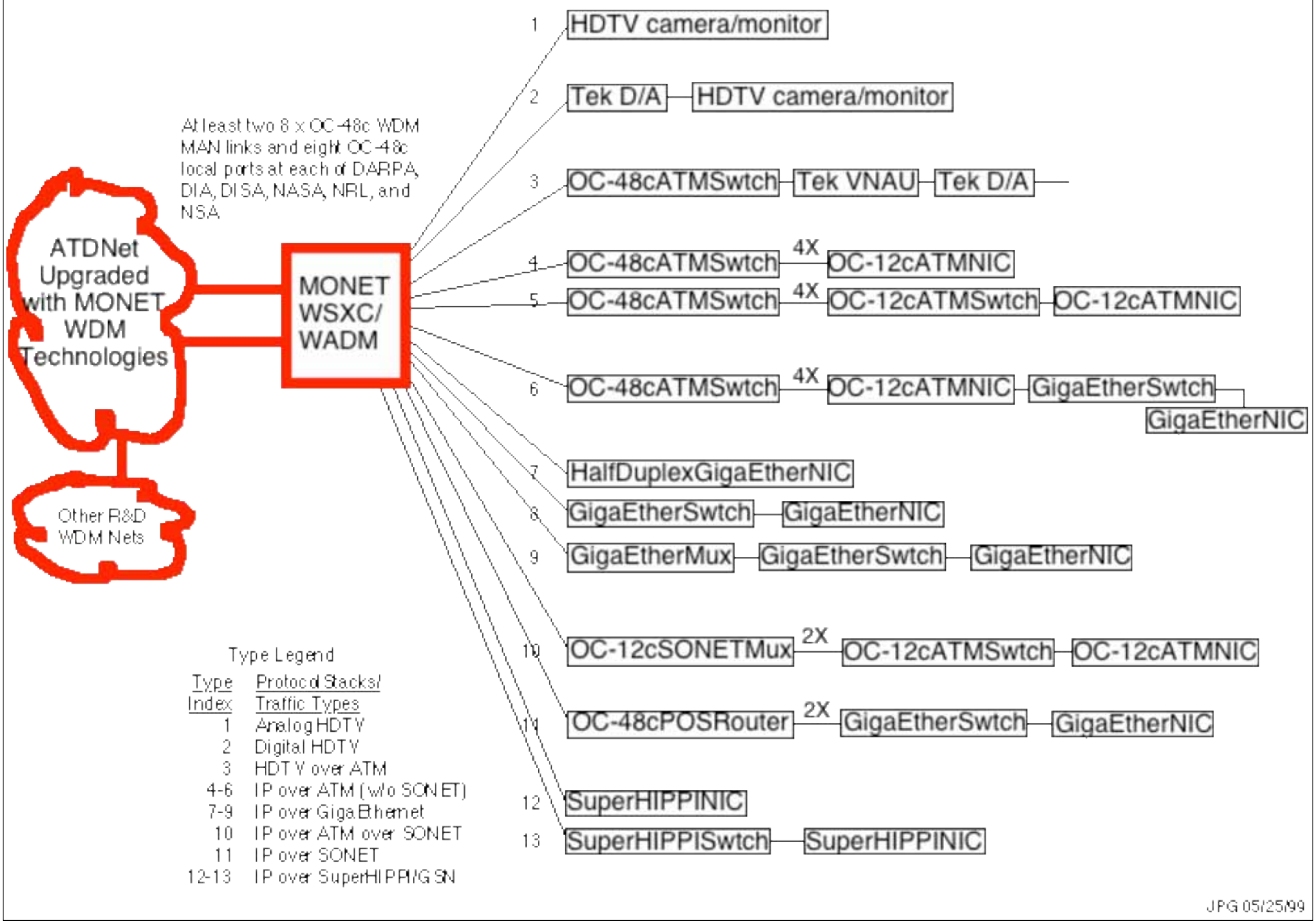
- Earth Science
  - » L-net extensions to CSU and GISS
  - » Lead NASA's science application challenges as the principal Earth science partner in NASA's emerging cyberinfrastructure program
- Space Science
  - » Requirements identification initiated with GSFC's Director of Space Sciences Dr. Dr. Jonathan F.Ormes
  - » Potential initial candidates include LISA and SDO
- Engineering/Flight Projects
  - » IDC: enabling interactive 3-D geometric design and planning simulations
  - » Potential missions: EOSDIS "follow-on", GPM, NPP, Blue Horizons

Research and Development of High-End Computer Networks at GSFC

Backup Charts


GSFC as part of NGI Supernets
SupernetNTON2
(OC192c x 4 WDM)
- Seattle
- Beaverton
- Bay Area
- LA, w/OC12c–HSCC
- San Diego
SupernetHSCC
(IP/SONET@OC48c)
- LA, w/OC12c– NTON2
- Denver
- Pittsburgh
- DC, w/OC48c–ATDNet
- NY
SupernetMREN/NRAMP
(OC48c x 8 WDM)
- Boston
- NY
- Philidelphia
- Wilmington
- DC
Abilene
(IP/SONET
@OC48c)
- initially 10
cities, 37 sites
(2/24/99)
vBNS
DREN
ESnet
NREN
NGIX's
- Chicago
- West
- East
MAX
UMCP
Juniper
M40
FORE
ASX4000
Nortel
SADM
IP/SONET
IP/ATM
IP/ATM/SONET
HDTV
HDTV/ATM
DARPA
NSA
BA
CO
ATDNet/MONET
DISA
NASA
Cisco
GSR12012
GSFC
High End
Computer
Network
Testbed
West
Ring
East
Ring
DIA
NRL
NRL LAN
Tellium
OC48c x
8 WDM
Lucent
OC192c x
8 WDM
WAMP
WADM
WSXC
OC48c/
2.4 Gbps
JPG 04/30/99

Different Protocol Stacks/Traffic Types in ATDNet/MONET



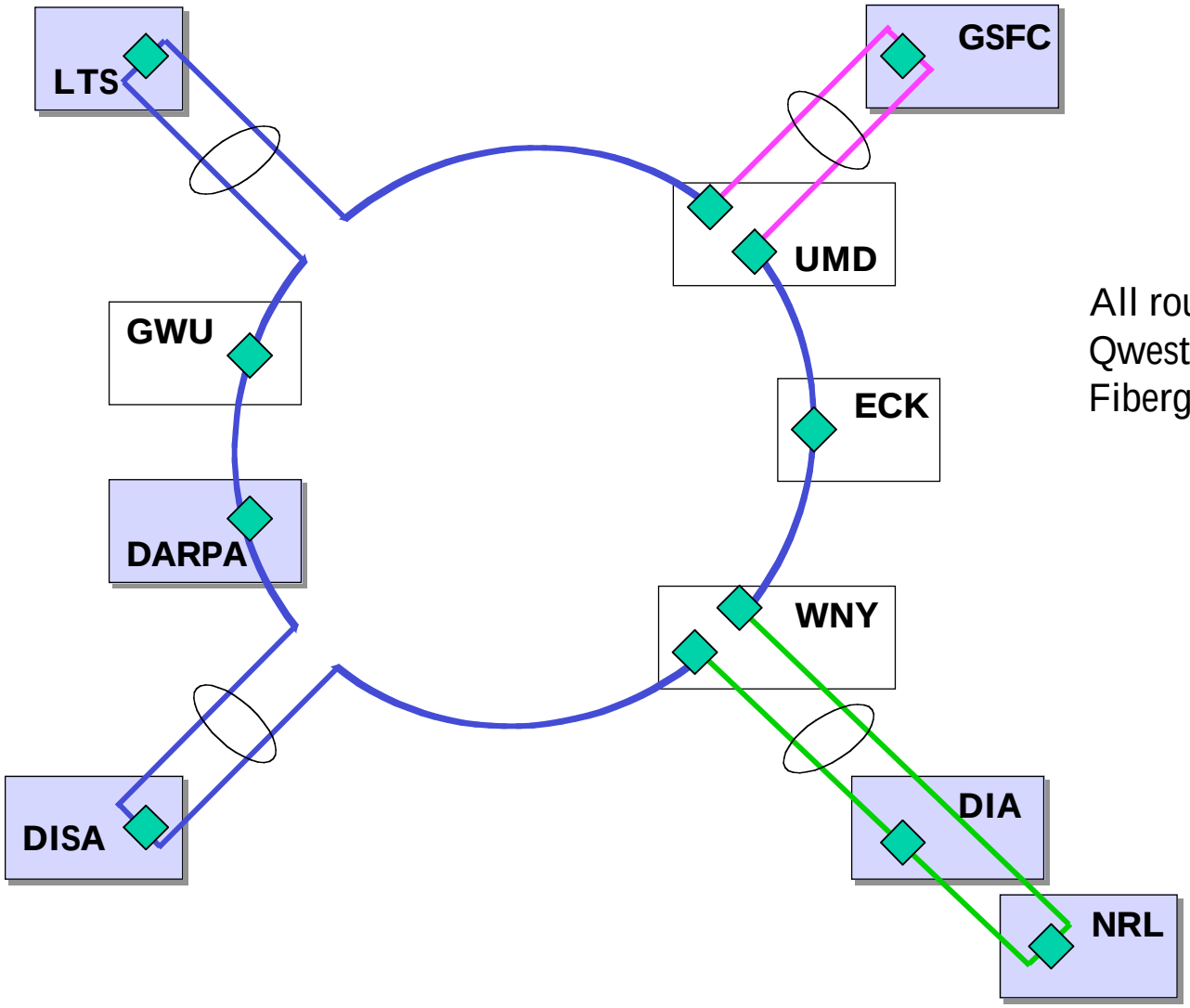
Type Legend

Type Index	Protocol Stacks/ Traffic Types
1	Analog HDTV
2	Digital HDTV
3	HDTV over ATM
4-6	IP over ATM (w/o SONET)
7-9	IP over GigaEthernet
10	IP over ATM over SONET
11	IP over SONET
12-13	IP over SuperHIPPI/GSN

JPG 05/25/99

ATDnet(V2) Ring Topology

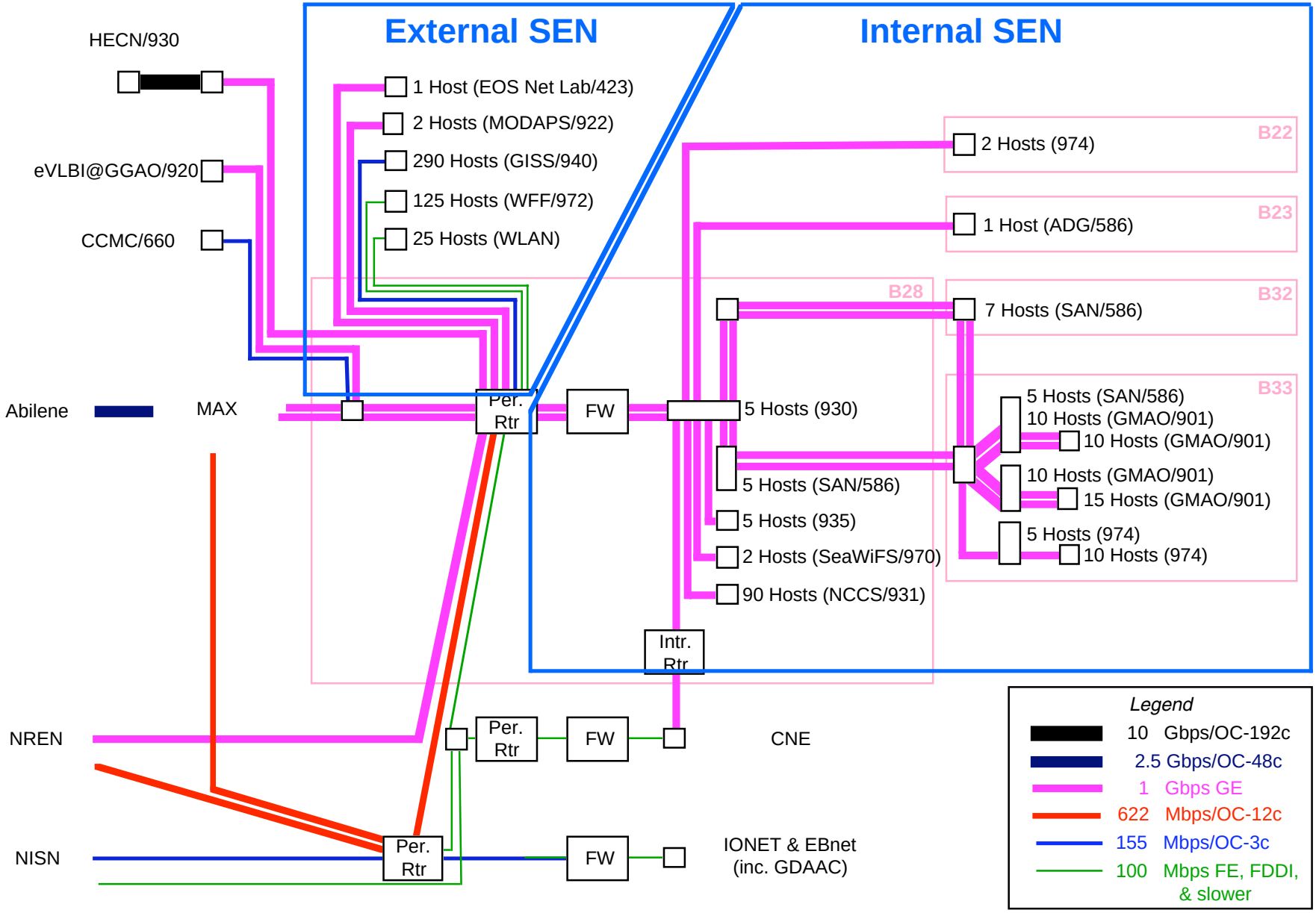
Basic configuration using Qwest to reach LTS



All routes are 2 strands fiber
Qwest routes are Lucent Truewave
Fibergate routes are SMF28

Fiber bundle
Cross-connect
Primary site
Ancillary site
Qwest fiber
Fibergate fiber
Govt supplied fiber

GSFC SEN Users (Internal and External) and Interfaces with Some Other Key Networks



JPG 10/10/03

Ethernet Jumbo Frame versus Standard Frame: Effect on Data Access Performance

(Tests Performed by GSFC's Bill Fink, 10/30/02)

- Test configuration
  - Data Server: Maximum Throughput Sledgehammer SH 200 network attached storage
  - Data Client: 867 MHz Macintosh G4
  - Access Protocol: NFS v3.0
  - Interconnection Network: Extreme Network Summit 51 Gigabit Ethernet switch (includes jumbo frame capability)
- Performance (MegaBytes per second) with jumbo frames (MTU=9000, NFS rsize=8192,wsize=8192)

<----------Transmit---------->			<----------Receive---------->		
Min	Avg	Max	Min	Avg	Max
38.1592	38.4785	38.8381	36.0036	44.9774	52.7600

- Performance (MegaBytes per second) with standard frames (MTU=1500, NFS rsize=1024,wsize=1024)

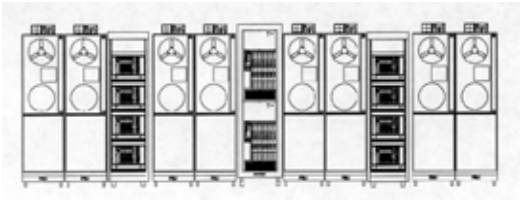
<----------Transmit---------->			<----------Receive---------->		
Min	Avg	Max	Min	Avg	Max
4.6198	4.6387	4.6593	4.6263	4.6392	4.6456

Schematic of Gbps e-VLBI Demonstration Experiment

Westford

~1.5 km

Mark 4
Correlator



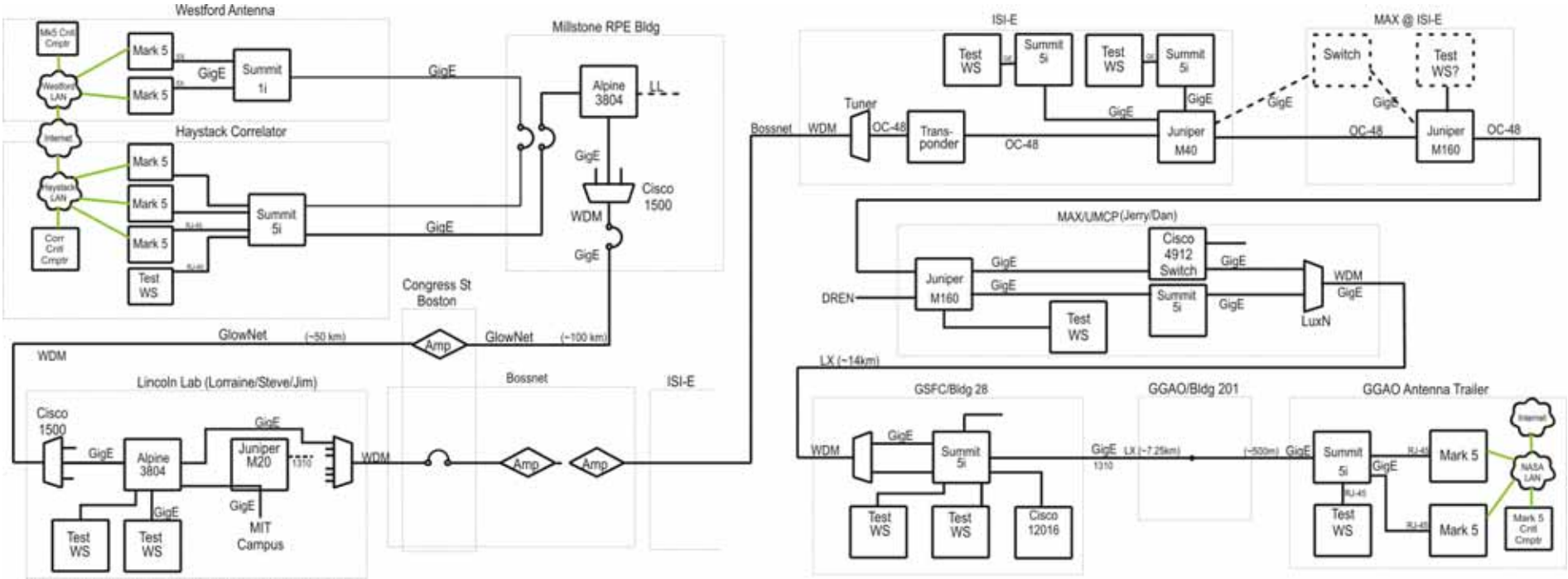
Haystack Observatory

~650 km

NASA/GSFC

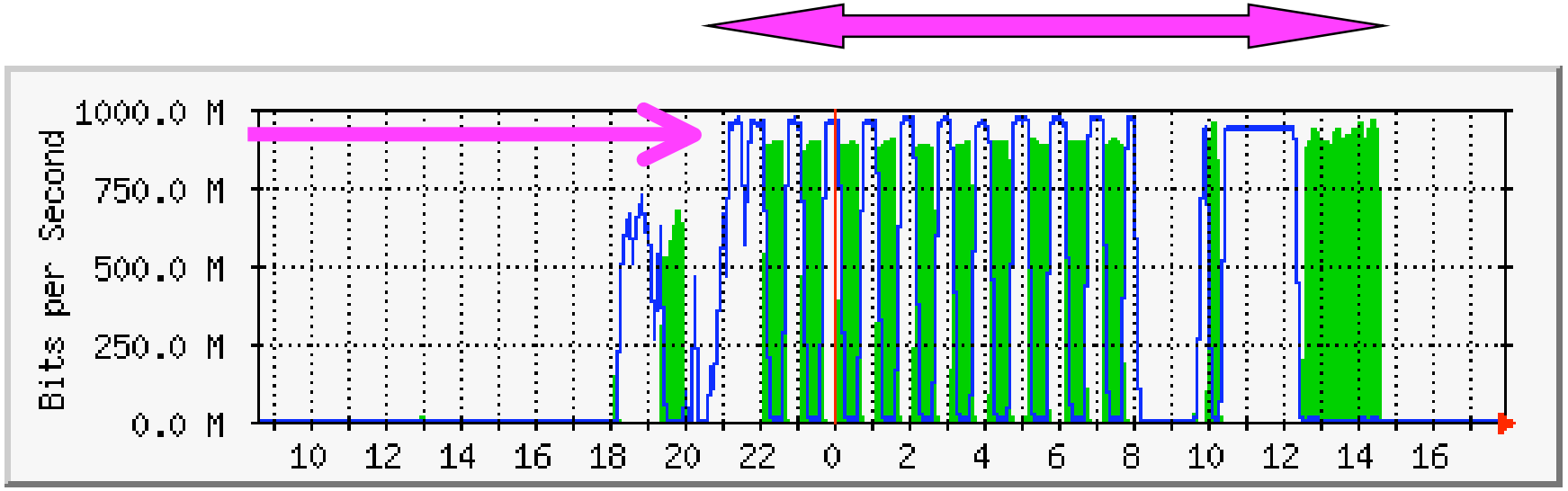
Glownet, Bossnet, MAX, NASA/HECN network segments

Details of the e-VLBI Network Path



For more info see ftp://web.haystack.edu/pub/e-vlbi/demo_report.pdf.

e-VLBI GGAO-Haystack Data Rates Sustained During a 16-Hour-Long Evaluation Test



Max In:970.5 Mb/s (97.1%) Average In:210.8 Mb/s (21.1%) Current In:168.0 b/s (0.0%)
Max Out:978.1 Mb/s (97.8%) Average Out:263.6 Mb/s (26.4%) Current Out:216.0 b/s (0.0%)

GSFC
Pilot SAN